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Mass migration of earthworms in Mawlyngot area, East Khasi Hills, Meghalaya

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Abstract

This paper documents the mass migration of the earthworm, *Perionyx macintoshi* that occurs annually in Mawlyngot area in Meghalaya, North-East India. Multiple field trips were conducted to this place for four years from 2011-2015 to study this phenomenon. Following field observations, the authors have made an attempt to explain the 'when', the 'why' and the 'how' of this migration.

Keywords: Mawkynrew Block, North-East India, *Perionyx macintoshi*, Uphill Migration

Introduction

Sometime in 2011, a local electronic media broadcasted on the unique mass migration of earthworms in Mawlyngot area in Meghalaya that pique the interest of the authors to take up this study. Previous information on earthworm migration dates back to more than four decades, and dealt with one-way mass migration – either uphill or downhill. This study therefore is significant as it forms the first report of the two-way mass migration of earthworms.

Physiology plays an important and foundational role in animal migration (Bowlin *et al*., 2010; Jachowski & Singh, 2015), the 'predictable, directional and persistent' movement underlying physiological changes that maximizes survival and reproductive success through the utilization of key habitats, food sources and breeding grounds and/or the avoidance of adverse environmental conditions (Dingle & Drake, 2007). Not much is known about migration of lower animals like earthworms, even though there have been reports of this phenomena occurring in India and Myanmar (Gates, 1972; Reddy, 1980; Julka *et al*., 1984). Earthworms are known to move vertically up to the upper layers of the soil during the warm and wet seasons, where they spend a good part of their life in feeding, reproducing, and other physiological activities. When the cold and dry season sets in, they move vertically down to the deeper layers of the soil to escape the cold and prevent desiccation. However, migration of these invertebrates from one habitat or ecological niche to another is largely unknown or documented.

Gates (1972) reported mass migration of earthworms in Myanmar (Chin Hills), as well as, made an unspecific reference of its occurrence in India. Reddy (1980) reported such migration of earthworms from Nagaland, North-East India, while Julka *et al.* (1984) reported a similar phenomenon from Shimla Hills, North India. As all these reports were based upon chance encounter in these localities, except for the unidirectional uphill/downhill migration and the generic and/or specific identity of the concerned earthworms, there was no detailed study on the various aspects of the migration like the purpose, the environmental factors, the navigation technique, the threat factors, etc. The present report therefore, assumes significance as an attempt is made to address these aspects.

Material and Methods

Multiple surveys were conducted at Mawlyngot between September, 2011 and May, 2015 to study the migration of earthworms, especially around the migratory seasons. Gates (1952) was followed for the identification of the earthworms.

The Study Site: Mawlyngot (N: 25.3837°; E: 91.9701°; 1624m) is a hamlet under the Mawkynrew Block of East

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Figure 1. Mass migration of earthworms at Mawlyngot. [Courtesy: Late J. S. Shangpliang of RiKhasi Channel, Shillong].

Khasi Hills District, Meghalaya. Mawlyngot (*maw*= rocks, *lyngot* = very heavy; in *Khasi*) derived its name from the rocky terra/strata that dominates the harsh topography. The rocky plateau of Mawlyngot is oriented in a northeast-southwest axis. Three main rivers – *Um* Stew, *Um* Song and *Um* Ñiuh - drain the valleys around this area (*Um*= Stream/River; in *Khasi*). *Um* Stew and its feeder streams drain the valley on the north that flow south-west to join *Um* Song; the latter and its tributaries drain the valley on the northwest, while *Um* Ñiuh and its tributaries drain on the southeast of Mawlyngot. Besides, numerous rivulets – both perennial and seasonal – drain the area. The only access to the migratory routes of the earthworms is by arduous treks on forest trails from the top of the plateau down the steep ravines (Figure 2). The area experiences heavy rainfall with dense fog during summer, and very cold and dry winters. The virgin forests are of subtropical with dense undergrowth of wild flowers, wild fruits, orchids, ferns and moss, and harbouring a myriad of birds and insects.

Results

Species Identity

These migratory earthworms, known only as the 'Blue Worms' because of their beautiful blue colour (Figure 3), belongs to the genus *Perionyx*, though not certainly fit with the same migratory species that Gates (1972) had reported. Based on the following diagnostic characters (Gates, 1952), the migratory earthworms in Mawlyngot

Figure 2. The terrain of the migratory sites of the earthworms, with the distant view of *Um* Song River.

area is conferred to *Perionyx macintoshi* Beddard, 1883 (Annelida: Oligochaeta: Megascolecidae).

Post-monsoon specimens measured in the field ranged from 200-350 mm in length, and 12-15 mm in diameter; of an iridescent blue colour, and mostly aclitellate. Pre-monsoon specimens are comparatively smaller in size of between 150-180 mm in length, less than 10 mm in diameter, and less blue (more brownish-red) in colour. Number of segments is approximately 265-280. Prostomium epilobous. First dorsal pore in 5/6. Spermathecal pores on 7/8-8/9 as large transverse slits. Clitellar modification of epidermis not easily recognizable, except for the slight change in colour distinct from the blue of other segments in some of the specimens, and the female pore is median and presetal on 14, though not distinct in most specimens. Male field transversely or longitudinally elliptical, pale, somewhat transversely wrinkled or grooved, reaching slightly onto segments 17 and 19, with the minute male pores in the deepened lateral portions of the groove.

Remarks: This species of 'blue earthworm' closely resembles *P. macintoshi*, however, its specific identity is still uncertain as it lacks a distinct clitellum and reproductive fields. It is of interest to note that in the hundreds of migrating individuals, not a single specimen was observed to possess a clitellum. Presumably, they were in the presexual or postsexual, aclitellate stage as reported by Gates (1952) on the type specimen of *P. macintoshi*. The species, like most species of the genus, is epigeic in nature.

Field studies and Observation

The study was carried out, particularly to the areas around *Um* Stew and *Um* Ñiuh. Our field data points to the fact that the mass migration of earthworms in this area is a seasonal round-trip migration that occurs every year: once at the onset of the monsoon (herein called the '*uphill spring migration*') and the other at the end of the monsoon (herein called the '*downhill autumn migration*').

The uphill spring migration starts in April-May each year, coinciding with the onset of the monsoons, when the earthworms emerge from the rivers and streams where they 'overwinter' under the rocks. Their emergence is, probably, triggered by the increased flow of water in such rivers and streams signaling the arrival of the rains. Their uphill journey begins in the early hours of the day (around 5:00-6:00 AM) when they ascend in batches of over a hundred individuals at a time, for 5-7 consecutive days, and in extended numbers of days in case the rains are intermittent. By 8:30-9:00 AM, the earthworm masses are no longer seen on the forest trails, having moved to the dense undergrowth of the forests, away from the desiccating power of the sun. There have been occasions when it stopped raining in Mawlyngot area for more than a week after the first or second batches of earthworms have already completed their spring migration, but it rained in other areas from where feeder streams flow to join

Figure 3: The 'Blue Earthworms' of Mawlyngot, descending a steep rocky wall near *Um* Ñiuh River.

the larger rivers, (like *Um* Song and *Um* Ñiuh) that skirt around Mawlyngot. Taking the increased flow of water in these habitat as a cue of favorable condition for migrating, batches of earthworms emerge from the water but failed to complete the uphill migration as the prevailing dry conditions at Mawlyngot resulted in the earthworms getting desiccated before they could reach the protective shades of the nearby forests. From May to September/ October, it rains almost every day and the earthworms spend their life on these rain-soaked high grounds.

The downhill autumn migration begins in mid-October, generally, when the heavy rain stops and the area experiences only light, intermittent showers. There is a drop in the temperature, accompanied with the cold dry winds that signal the onset of the winter. A perceptible change in the vegetation ensues with the thick undergrowth drying and dying off as the soil dries up. The combination of these factors acts as cues that lead the earthworms to start their downhill migration to the rivers and streams to avoid desiccation.

Timing is of utmost importance during the downhill autumn migration; any deviation and the earthworms will fail to reach their favoured destination. In October, 2013, we have observed hundreds of earthworms, all in a line, having died of desiccation before they could reach the water-body down in the gorge. That particular year, the rain stopped abruptly in September-end after a shower that lasted for 4-5 days, and the usual intermittent rains signaling the end of the monsoon was entirely missing. The dense undergrowth and the mosses dried off within a short span of time. This triggered the earthworms to begin their downhill migration, but the earthworms died of desiccation before reaching their destination. The rocky hillside strewn with long lines of dead carcasses of the blue earthworms were all we could find during that trip. The carcasses were seen being feasted by ants.

Figure 4. Earthworm clump under water during the downhill autumn migration.

Discussion

Migratory animals are very sensitive to environmental changes as they have evolved to respond to external environmental cues that tell them "it's time to move" (Gwinner, 1996). During the study it has been observed that environmental changes, like changes in the local temperature, precipitation, wind velocity, season, etc. directly or indirectly impact the earthworms, through the ability of these factors to influence the soil and vegetation of this area. The amount of precipitation determines the water content of the soil, which in turns affects the vegetation that the soil can support. Moreover, the precipitation rate is a decisive factor in increasing or decreasing the flow of water in the rivers, in the absence of which, the wind exerts their effect through its influence on the transpiration rate of the vegetation and accelerates the loss of moisture from the soil. These various environmental factors, individually and/or in conjunction with each other, act as cues that 'tell' the earthworms when and where to migrate. During our study, we have found that the migratory earthworms (*P. macintoshi*) tide over the dry, cold winters by migrating downhill to the rivers and streams in the area. As the respiratory and excretory physiology of the earthworms closely resemble those of aquatic animals, it is not uncommon for earthworms to be found in an aquatic habitat; and there are a few species that are exclusively found in such habitats or that appear to have evolved to freely move between aquatic and terrestrial habitat (Lee, 1985). *Perionyx macintoshi* could be a representative of the group of earthworms that are able to adapt to live in both terrestrial and aquatic habitats.

Migrating animals travelling long distances between habitats require adaptation to optimize energy outputs by preparing themselves for the long journey (Gwinner, 1996), as a successful migration depends on how much energy is available for the purpose. Therefore, accumulation of fuel in the form of food reserves in the body is an essential mechanism supporting migration (Lennox *et al.*, 2016).

It is not known with certainty if such high intake of food is also ingested by this migrating species of earthworms, but from the obvious increase in the body mass of the aclitellate individuals that partake in the downhill autumn migration, we believe that these earthworms do have some kind of preparatory mechanism in place that may play a role in the assimilation of energy for the downhill migration and the extended stay in their over-wintering habitat. One such mechanism could involve the endocrine system, whereby the annelid hormone 'switch off' the gametogenic regimen/reproductive phase of the earthworm, as evident from the aclitellate appearance of the earthworms, to facilitate the diversion of energy reserves towards migratory movements.

Migrants have to navigate to their destination habitat; many mechanisms have been proposed from time to time to explain how the migratory animals navigate. *Perionyx macintoshi*, probably, navigates between habitats using the geomagnetic field, as the absence of eyes precludes other visual-based orientation mechanisms (Kimchi *et. al.,* 2004). Vidal-Gadea *et al.* (2015) has identified a magneto-sensory neuron that mediates geomagnetic orientation in the soil-dwelling nematode *Caenorhabditis elegans*. Similar such neuron could probably exist in the earthworms, too, that would enable it to acquire a 'magnetic map' of its habitat and use it to navigate towards its destination. To prove or disapprove this is a new scope of work for future workers.

Both the spring and the autumn mass migration of the migrating earthworms take place during the early morning hours. A probable explanation to this may be attributed to the metabolic effect of the warm rays (less than 25°C) of the rising sun. Any temperature rise above 25° C increases the respiratory (metabolic) rates in earthworms (Šustr & Pižl, 2010). Migrating at the break of dawn, therefore, makes sense; the earthworms derive the benefit of an enhanced metabolism without expending the food reserves, for the journey.

Herding behavior of the earthworms during the time of mass migration is observed. Such collective movement is a dominant characteristic of migratory animals. Zirbis *et al.* (2010) had documented the intra-specific collective movement in the earthworm species *Eisenia fetida*, highlighting the consensual decision phenomenon based only on contact between followers and, thereby, showing how earthworms influence each other to select a common direction during migration. Possibly, this consensual decision making may be a shared characteristic of all migratory earthworms. This would explain the aggregation and collective movement we have observed in *P. macintoshi* in Mawlyngot area. Another migratory behavior observed is that when migrating on land they move in masses or 'herds', but when nearing the water body they form tight 'balls' or 'clumps' consisting of hundreds of individuals that roll down like a ball and drop down into the water (Fig.1 and 4). This clearly is a protective mechanism that the earthworms use to prevent being predated by the fishes. Once in the water, these balls of earthworms detangle and move under the huge rocks or boulders lying in the hill streams.

Factors Threatening the Mass Migration of *P. macintoshi*

Factors like anthropogenic/developmental activities, predation, erratic weather patterns, climate change, etc. pose risks to successful migrations. Migratory animals face unique challenges adjusting to anthropogenic environmental changes because when migrating they continuously gather information, both external/environmental and internal/physiological; they co-ordinate these sets of data gathered, and accordingly make decisions as to the timing and orientation of migratory movements (Winkler *et al*., 2014). Since these are evolutionary changes, they are a gradual and comparatively slow process that lags behind the rapid environmental changes, thereby, increasing the possibility of de-synchronization between behavioural and environmental conditions that would be detrimental to the migrants. This may result in failure to migrate on time or not migrate at all. Either way, the death of such population is certain; or if multiple populations of the migratory species face such circumstances, the threat of extinction increases.

During our study, we have noticed unsustainable land-use practises in the area. There is an on-going road-connectivity work involving earth-cutting for connecting and developing several small villages in the area. In this connection, some stones quarries have sprung up in the area. One such rock-cutting and excavation quarry has been commissioned right on the migratory route of *P. macintoshi* (Figure 5). As the migratory paths, often, are the same year after year, we had made this particular spot a target area for studying the response of the species to the human-induced change in the habitat/environment. In the initial year (2011), the earthworms appear to be

Figure 5. Stone quarrying along one of the migratory routes.

unaffected by the changes in their migratory path, as the rock-cuttings exposed water springs embedded in the rocks around the newly excavated strata keeping the surrounding soil and gravels sufficiently moist and conducive for the earthworms to move. However, by the following year, the stone quarrying had intensified and the water spring was just a trickle. Hence, the authors did not encounter the masses of moving earthworms in that spot in the subsequent years, though a few worms were seen lethargically wriggling in the almost dried up soil.

Positive Impact of the Mass Migration

The mass migration of *P. macintoshi* has a positive impact on the soil of Mawlyngot area. The usual activities of the earthworms, tills and turns the soil, releasing and recycling the nutrients from the dead and decaying organic matters, enriching the soil. Besides fertilizing the soil their activities also aerate the soil and increase the percolation of rain water to the deeper soil layers.

The locals, having the wisdom to understand the role these earthworms play in enhancing the fertility of soil on their land, have shifted to ecologically sustainable organic farming. Many of them have taken to organic tea cultivation as an alternative source of livelihood, and simultaneously decreasing their dependence on broom grass cultivation. Marketed under the brand, '*Urlong*' (meaning, '*dreams come true*'), the organic tea cultivation has emerged as a major source of livelihood for the locals. Such kinds of sustainable activities will go a long way in protecting these earthworms, ensuring their survival and repeated occurrence of the mass migration phenomenon.

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